GROUNDWATER QUALITY INVESTIGATION
FOR
CHEMCLENE CORPORATION
FRAZER, PENNSYLVANIA

Problem Definition
with
Recommendations for Clean-up

November 1981

Prepared for the

CHEMCLENE CORPORATION
258 N. Phoenixville Pike
Malvern, Pennsylvania 19355

Prepared by

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INTRODUCTION

Background

Chemclene Corporation sells and recycles industrial cleaning solvents. For over 30 years, they have maintained a successful and innovative recycling facility at their present location in Frazer, Pennsylvania. The founder of the corporation, the late Mr. Lloyd Balderston, was an ardent conservationist and past president of the Valley Forge Chapter of the National Audubon Society.

The Chemclene Corporation sells and reclaims the following four chlorinated hydrocarbon based cleaning solvents:

1. Trichloroethylene (TCE)
2. 1, 1, 1-Trichloroethane
3. Perchloroethylene (PCE) also called Tetrachloroethylene
4. Methylene chloride

These solvents are used by their many industrial customers throughout the Delaware Valley for degreasing and other cleaning purposes. Chemclene Corporation has developed particular expertise in reclaiming spent solvent using a distillation process. The distillation process results in the removal of impurities from a particular solvent so that it can be returned to a customer for reuse. Removal of impurities from various solvents results in the formation of small to moderate quantities of sludge. At present, all sludge is being sent to an approved disposal facility in Alabama.

During the spring of 1980 when media attention was focused on TCE problems throughout Montgomery and Chester Counties, the Chemclene Corporation decided to sample selected wells in the immediate vicinity of their property. While there had been no major spills or leaks of solvent during

their 30 years of operation, sampling was never the less undertaken as a precautionary measure. When some of the wells sampled were found to contain TCE levels greater than 4.5 ppb, appropriate officials with Pennsylvania's Department of Environmental Resources (DER) in Norristown were notified. As a result of their initial findings, the Chemclene Corporation immediately began taking steps to investigate and rectify any potential contamination problem eminating from their property. These steps included:

1. Sampling all nearby wells to determine if any chlorinated hydrocarbons were present.
2. Engaging the services of Moorshead-Siddiqui and Associates, groundwater geologists, to investigate the problem.
3. Meeting with DER officials on-site and in Norristown to discuss the problem and to develop solutions.
4. Installing carbon filters on all household systems where levels of TCE were above 4.5 ppb.
5. Reviewing material handling procedures and facilities in their plant to prevent any future spill or leak from reaching soil and possibly contaminating ground water.

As a result of Moorshead-Siddiqui and Associates initial investigation, it was determined that at least two areas on the Chemclene Corporation property were likely sources of groundwater contamination. These areas included the plant area on the east side of the property and a former disposal area near Hillbrook Circle on the west side of the property.

Site Locations

Chemclene Corporation is located on over 100 acres of mostly wooded property situated on the southeast slope of Bacton Hill in East Whiteland Township, Chester County, Pennsylvania (see Figure 1). As Figure 1 indicates, the plant area and the former disposal area are situated approximately 2,500 feet apart along the base of Bacton Hill. Access to the former disposal area is along an abandoned railroad right-of-way which crosses Phoenixville Pike near the entrance drive leading to the Chemclene plant. Parallel

and to the north of the railroad right-of-way is the right-of-way of the Transcontinental Gas Pipe Line. It appears that during the construction of the gas pipe line in 1951 or 1952 that an excavation had been made at what is now called the former disposal area. Slowly, over the years, that original excavation was refilled with rusted and unuseable drums, discarded equipment, family trash and excavated soil. As far as can be determined, the excavation was not used to dispose of sludge or any other active waste material.

The area surrounding the Chemclene Corporation property has gradually changed over the past 30 years from open farmland and woods to one-acre, single family residental developments and industrial parks. Development in the area is typical of that which is taking place in most suburbs surrounding the City of Philadelphia. Hillbrook Circle, a development of approximately 35 homes, was built between 1956 and 1959 south of the Chemclene property. Additional developments to the north and east of the Chemclene plant were built during the mid 1970's.

Previous Investigations

Much data concerning wells, water levels and the hydrogeology of the Chemclene Corporation area had been developed during investigations undertaken in 1977 and 1978 on behalf of Hillbrook Circle and other area residents. At that time it was alleged by area residents and their consultant, Moorshead-Siddiqui and Associates, that when the Philadelphia Suburban Water Company placed their Great Valley Well (see Figure 1) into operation it adversely effected a number of domestic wells in Hillbrook Circle. It was suggested by Philadelphia Suburban Water Company's consultant; Leggette, Brashears and Graham, Inc.; that water level declines in Hillbrook Circle wells were due to a general lack of recharge during that period and the pumping of large quantities of groundwater from limestone quarries in the Devault area.

LOCATION MAPS
FIGURE 1

Project: Chemclene

Well Chemclene Project

State: Pennsylvania

Portion of USGS Quad: Malvern 7½

County: Chester

Town/Township: East Whiteland

Street: Phoenixville Pike

Tract: —

Topographic setting: valley + side hill

Physiographic province: Piedmont

Geologic formation: see text

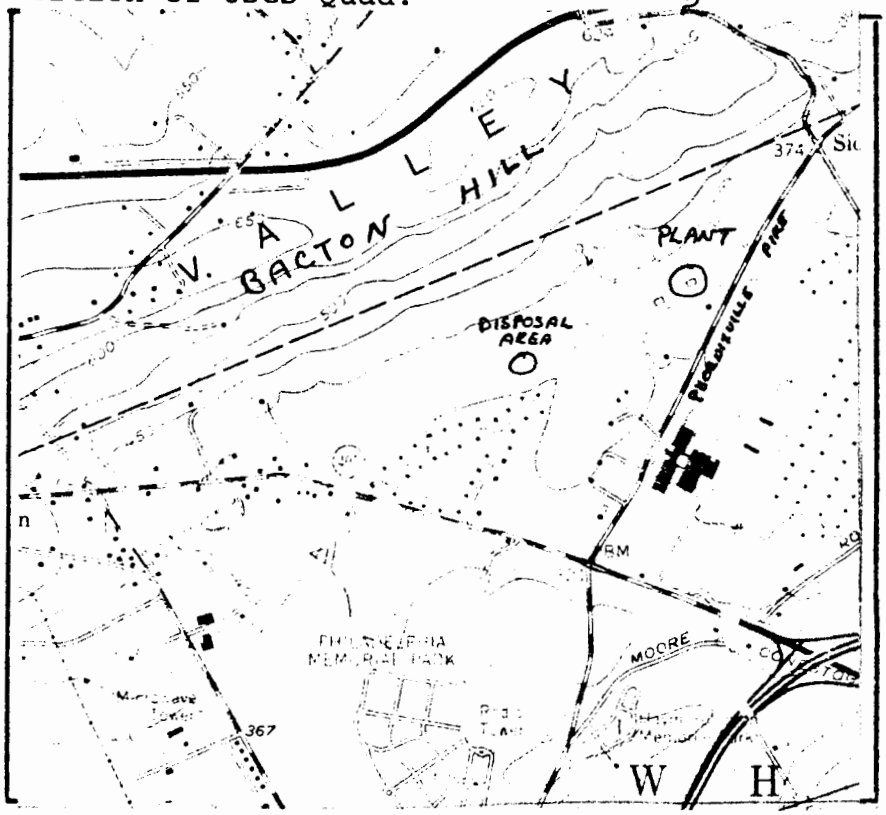
Longitude: —

Latitude: —

Elevation at surface: 300'-400'

Flood elevation: none

Flood potential: none



Date:

Scale: 1=2000'
Contour Int: 10'

Locations also plotted:

SITE PLAN

Access problems:

none

see airphotos and 1" = 400' line drawings.

Site plan prepared by:
T. Moorshead

Identified on plot plan:

- ✓ wells
- ✓ springs
- ✓ pipelines
- ✓ surface water bodies
- ✓ roads
- property l'ns
- electric l'ns

Site/Well identified by:

casing

Completed by: T. Moorshead.
Date: 9/81

Date:

Scale:

Between the ground surface and underlying solid bedrock is a zone of weathered material called the overburden. The overburden thickness in the area varies from a few feet near bedrock exposures to probably depths of between 100 and 150 feet at the centers of incipient sinkholes (in the carbonate rocks). Overburden materials consist mostly of clay and silt with some residual rock fragments and sand lenses.

Groundwater Flow

While topographic drainage patterns in the area would seem to indicate that all subsurface flow should drain towards Valley Creek and toward Philadelphia Suburban Water Company's Great Valley Well, water level data collected during the current investigation indicates that such is not the case. Groundwater movement in the bedrock under much of the Chemclene property appears to be toward the northeast, parallel to and along major faults. The groundwater discharge point (or sink) for this subsurface flow system is undoubtedly the deep quarries operated by the Martin-Marietta Corporation and the Warner Company in nearby Devault. Large amounts of ground water are pumped from these quarries for dewatering purposes. In addition to the influence which faulting and pumpage exercises on groundwater flow in the area, it is also probable that fracture zones and to a lesser degree bedding planes in the bedrock also influence groundwater flow. When rain or snowmelt enters the overburden (a process called infiltration), it moves vertically downward until the water-table is reached. The water-table is the upper surface of the zone of saturation. The water-table may be either in the overburden or in the bedrock depending on a variety of complex hydrogeological inter-relationships and man induced pumping. Depths to the water-table in the area vary between 0 feet at the surfaces of springs and some streams to more than 70 feet at other locations. Water levels fluctuate seasonally in response to groundwater recharge and groundwater

discharge to streams and wells. Due to large, man-induced withdrawals from the area (quarries in Devault and the Philadelphia Suburban Water Company's Great Valley Well) and recent recharge deficiencies, water level depths are much greater than normal. Water level declines have caused some springs to dry up and some shallow wells to be adversely affected. During parts of the year, Valley Creek enters a sinkhole near where it crosses Route 401 and does not start flowing again until a point 200 yards below the Great Valley Well. While delineating groundwater flow patterns is usually more difficult in carbonate rock terrains, the presence of a large number of accessible wells in the area made the work somewhat easier.

Groundwater Quality

It would be expected that natural groundwater quality in the vicinity of the Chemclene property would be good to excellent. Ground water in the non-carbonate rocks will tend to be acidic and have low total solids. Ground water in the carbonate rocks will tend to have a higher pH and greater amounts of total dissolved solids. Ground water in the carbonate rocks will tend to be moderately to very hard but otherwise suitable for drinking water purposes.

An extensive amount of geochemical data has been collected by the Philadelphia Suburban Water Company since their Great Valley Well went into operation in 1977. This data to date indicates the presence of no unusual constituent (including chlorinated hydrocarbons) at any detectable concentration (personal communication with Richard Riegler, Philadelphia Suburban Water Company).

In addition to the Chemclene Corporation there are two other possible if not probable sources of chlorinated hydrocarbon contamination in the area. These sources include illegal dumping along the pipe line and railroad right-of-ways and the use of a variety of septic system cleaners by local area residents. Hillbrook Circle in particular has had a past history of on-site domestic waste disposal problems.

Groundwater Use In the Area

Most older homes in the area utilize on-site domestic wells. In the early 1970's, the Philadelphia Suburban Water Company began to extend public water service into the area. In 1977 the Philadelphia Suburban Water Company started to operate the high yielding Great Valley Production Well near the intersection of Route 401 and the Phoenixville Pike (see Figure 1). All homes, schools and businesses southeast and west of the Chemclene property toward Devault are presently provided with public water by Philadelphia Suburban Water Company. There are no public or private wells of any kind in this area and unless the water company decided to construct a production well in that area, it is doubtful that there will ever be any wells drilled there in the foreseeable future.

FIELD INVESTIGATION

Initial Sampling and Well Inventory

Most older homes in the immediate vicinity of the Chemclene property use domestic on-site wells for water supply purposes. In order to collect necessary hydrogeological and water quality data, all wells in the vicinity of the Chemclene property were inventoried and sampled. The inventory consisted of an expansion of a previous inventory of wells undertaken in 1977. The inventory added homes north and east of the Chemclene property and included some homes where wells had been drilled or deepened between 1977 and the present. The locations of all wells are indicated on Figure 3 and available information concerning each well is found in Appendix A. During the well inventory, permission was obtained from residents with accessible wells to periodically measure water levels in their wells. As part of the inventory of wells, water samples were collected for chlorinated hydrocarbon analysis. A total of 44 samples were collected by Chemclene personnel on May 8 and 9, 1980, and on June 13, 1980. The samples were immediately taken to Cedar Grove Laboratories

Even after a considerable field effort to collect data and much debate concerning the analysis and interpretation of that data no general agreement concerning the matter was ever reached.

During the 1977-1978 investigation all available wells in the area were inventoried by Moorshead-Siddiqui and Associates and Philadelphia Suburban Water Company personnel. The water company had a surveying crew determine the elevations of the measuring points of all wells and springs which were then measured on a weekly basis. Water level contour maps and well hydrographs were prepared. Leggette, Brashears and Graham, Inc. completed a report for Philadelphia Suburban Water Company in May 1979 entitled "Investigation of Alleged Interference by the Great Valley Well on Nearby Private Wells with Particular Emphasis on Hillbrook Circle." Data collected during the 1977-1978 investigation was of immeasurable value in conducting the present investigation.

Scope of the Present Investigation

Contamination of ground water under the Chemclene property may have begun as early as 1950 when the facility first went into operation. From that time until the spring of 1980, there had been no significant leaks or spills or even an awareness that spillage could conceivably cause a problem. The Balderston family lived on the property and depended for their entire water supply on a well located 175 feet from the plant (in a down gradient direction). During the last 30 years there was no hint that this well had become contaminated. No taste or odor problem had ever developed in the well which would indicate chlorinated hydrocarbons had entered the supply.

Because the problem in the Chemclene area is apparently an old one, a quick response to prevent the movement of chlorinated hydrocarbons into uncontaminated portions of the aquifer was not felt to be an issue. However, in order to delineate the extent of present contamination, prevent future

contamination and develop remedial measures, the following work plan was developed by Moorshead-Siddiqui and Associates and approved by DER:

1. Select monitoring well locations; based on a fracture trace analysis, the possible location of contamination sources, projected flow directions and the suitability of access for a drilling rig. Both 6" steel cased and 1¼" pvc wells will be constructed. Sites will be staked in the field and checked by a DER hydrogeologist prior to drilling.
2. Obtain soil samples and construct monitoring wells at designated locations. Mechanical rather than solvent-cement joints will be used to fasten screens to pvc pipe. All monitoring wells will be thoroughly developed to insure that representative water samples are collected.
3. Determine measuring point elevations on new monitor wells so that an existing water level contour map can be expanded to cover the former disposal area and the plant area.
4. Determine the extent of soil contamination and ascertain clean up procedures.
5. Test pump and sample all monitoring wells paying close attention to the cones of influence around each well and the potential yield of the 6-inch diameter wells since they might be used for removal purposes.
6. Measure water levels and sample specific neighboring wells to determine long term trends in flow directions and groundwater quality.
7. Assess the extent of the overall contamination problem and review possible alternative solutions with DER staff.
8. If possible, implement selected abatement techniques on a trial basis to determine their feasibility and cost.
9. Analyze all data and information to develop a proposed abatement plan. Present the proposed plan to DER for review and comments.
10. Prepare a final report containing all pertinent data and the agreed upon abatement plan.

SITE CONDITIONS

Topography and Surface Drainage

As indicated on Figure 1, the plant area and the former disposal area are both situated at the base of Bacton Hill.

Surface elevations at both sites are approximately between 365 to 275 feet above MSL. Surface drainage in both areas is toward the southwest and into Valley Creek. A surface water divide exists slightly to the northeast of the Chemclene plant and surface drainage over the divide would be toward a dry valley leading to the Devault and Cedar Hollow areas. The topography of the area is controlled for the most part by the composition of and the structures in the underlying bedrock. Less easily weathered and eroded quartzites are found under Bacton Hill and more easily weathered and eroded carbonate rocks are found beneath the valley at the foot of Bacton Hill.

Geology

The geology of the area, obtained from published geologic maps, has been superimposed on a base map used during the present investigation (see Figure 2). As the map indicates, the study area is underlain by the dolomites and limestones of the Elbrook, Ledger, Kinzers and Vintage Formations and the schist and quartzite of the Harpers and Chickies Formations. The former disposal area is underlain by the Ledger Formation, a light gray dolomite, which covers much of the study area. The plant area is underlain by the Elbrook Formation, a light gray to yellowish, siliceous limestone containing interbedded dolomite. The hydrogeologic properties of both of these bedrock formations are similar enough that they are treated as a single hydrogeologic unit for the purposes of this investigation.

The geologic map of the area indicates the presence of two major faults trending in a southwest-northeast direction across the area of the investigation. The northern most of these two faults follows the break in slope at the base of Bacton Hill and serves as the boundary between the metamorphic phyllite and quartzites up slope and the carbonate rocks out in the valley. Major faulting and subsidiary fractures and joints have a significant impact on groundwater flow in the area.

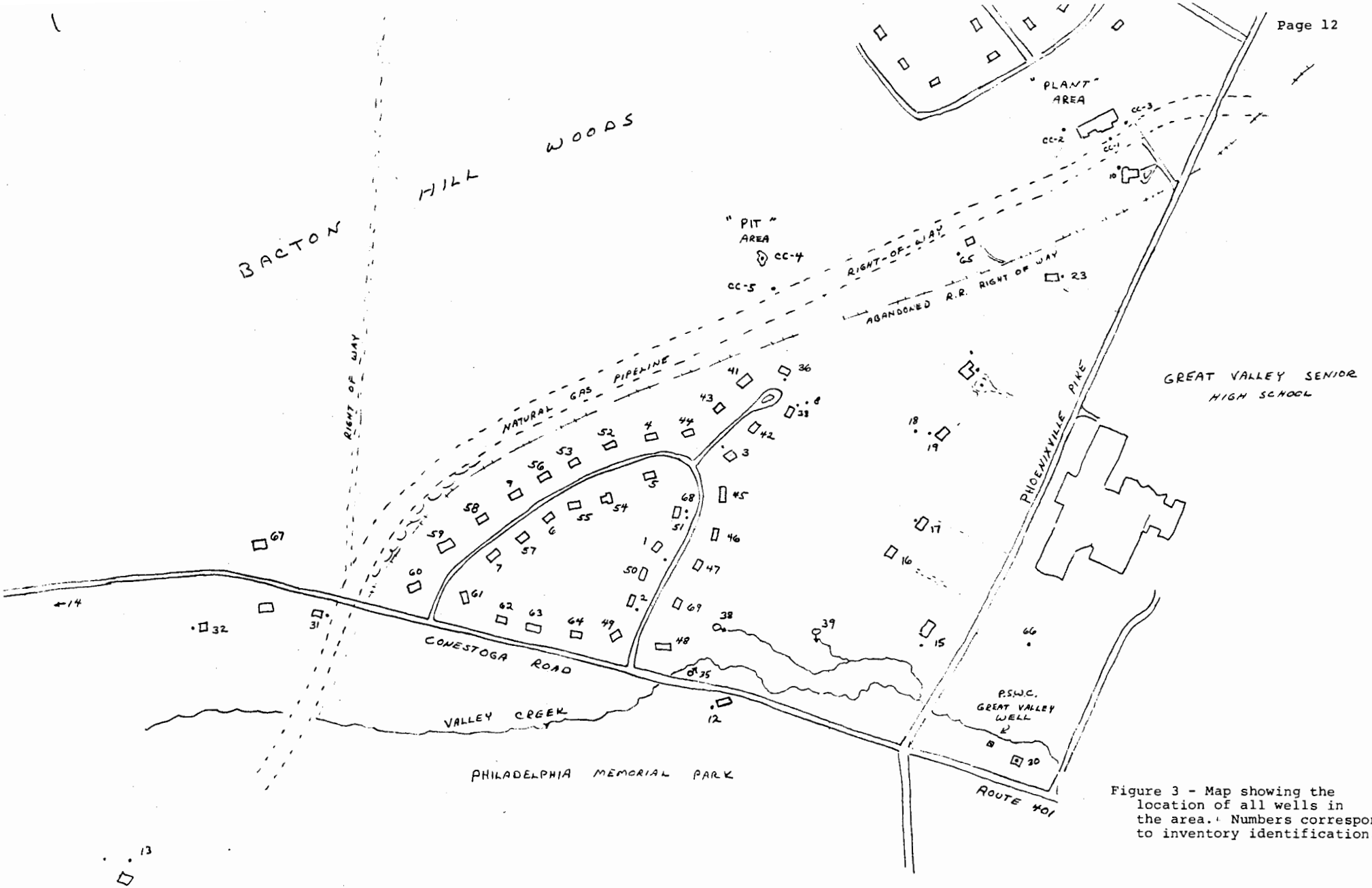


Figure 3 - Map showing the location of all wells in the area. Numbers correspond to inventory identification.

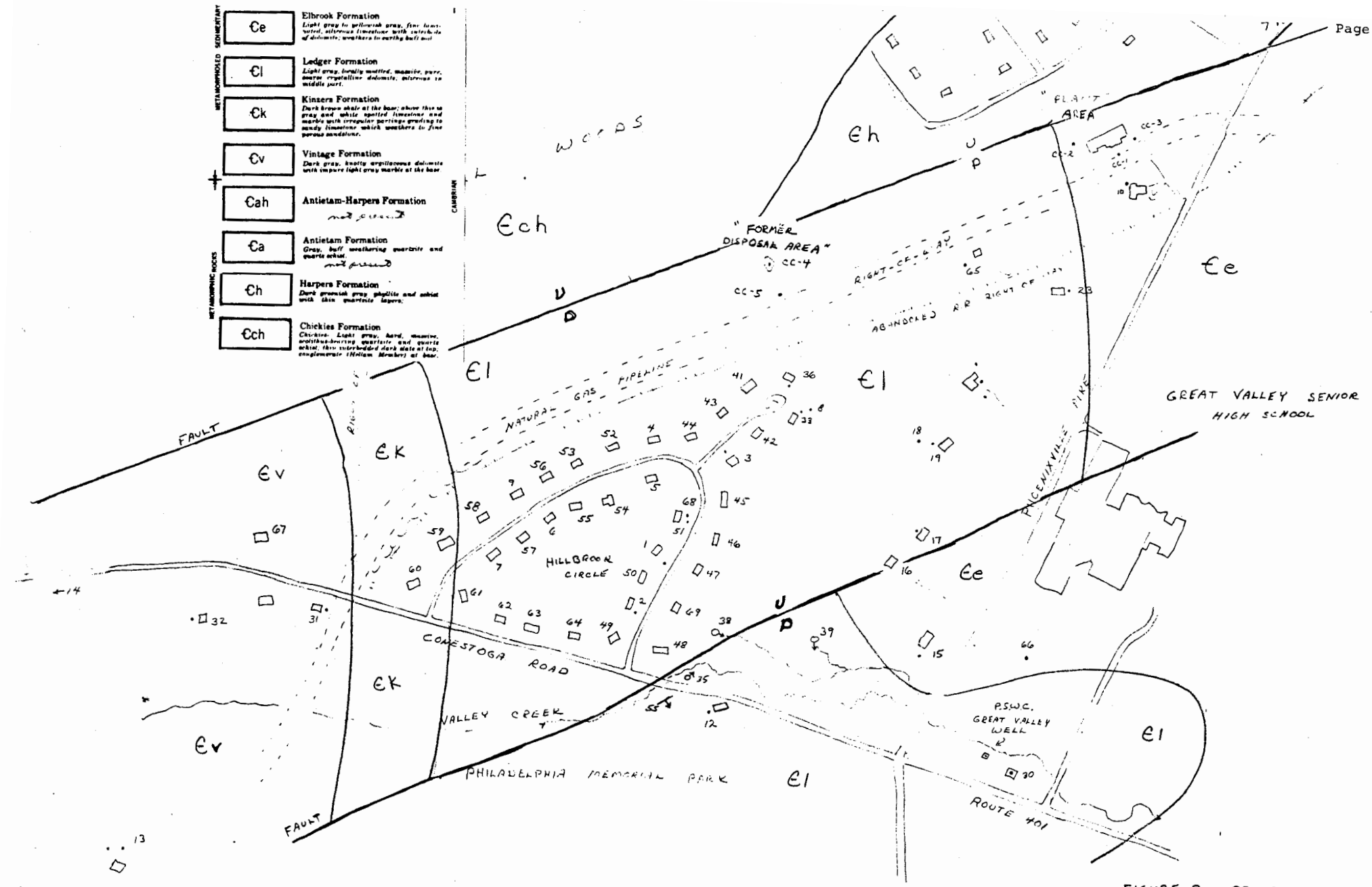


FIGURE-2 GEOLOGIC MAP

in Downingtown for analysis. The results of this analysis are found in Table 1.

A total of 11 wells had concentrations of TCE higher than 4.5 ppb. All of these wells were immediately equipped with treatment devices (as a precautionary measure) despite evidence that some of them were probably not contaminated by any activity on the Chemclene property.

Air Photo Analysis

Since groundwater flow patterns are controlled to a large extent by fractures and faults in the bedrock underlying the Chemclene Corporation property, an analysis of air photos was made to delineate the location of such features. A technique known as fracture trace analysis has been used successfully many times by Moorshead-Siddiqui and Associates to locate high-yielding water wells; and it was felt that locating monitoring wells along fracture traces would help to increase the likelihood that a high yield would be obtained. Obtaining a high yield from the monitoring wells was thought to be important for the following reasons:

1. The monitor wells had to be sampled with moderate capacity submersible pumps due to the anticipated depths to water.
2. Submersible pumps would also allow a relatively large volume of water to be pumped from each monitoring well thereby insuring that representative formational samples would be collected.
3. Certain monitoring well(s) could be converted to retrival wells (if necessary) in the future and a moderate to high yield would be advantageous for that purpose.
4. The well would provide water level data that was representative of the local flow system.

Stereo pairs of photographs taken in 1965, 1970 and 1975 were used during the fracture trace analysis. A composite large scale (1" equals 400') photograph from the 1975 flight was also used as a base map during the investigation. Most of the maps presented in this report were prepared from tracings from that composite photograph.

Test Drilling and Monitor Well Construction

As previously mentioned, there are two areas on the Chemclene property where chlorinated hydrocarbons probably entered the groundwater flow system. These areas are in the vicinity of the plant and at the former disposal area. In order to gain additional information concerning subsurface conditions in the vicinity of both of these areas, it was decided to drill test holes and to construct monitoring wells. Test drilling and monitor well construction was designed to accomplish the following:

1. Obtain site specific geologic information including overburden thickness and bedrock lithology.
2. Determine subsurface permeability information.
3. Provide a means to measure water levels.
4. Provide a means to collect water samples for quality analysis.
5. Provide a retrival well, if necessary.

Test drilling and monitor well construction began October 15, 1980, and was finished on October 17, 1980. Thomas G. Keyes, Inc. completed the work under the supervision and an inspection of Moorshead-Siddiqui and Associates' personnel.

Since depths greater than 50 feet were anticipated and there was the probability of encountering large residual rock fragments in the overburden, an air rotary drilling rig was used. A hydrogeologist supervised drilling, collected well cuttings, described samples and made decisions concerning monitoring well construction. Each monitoring well was constructed based on information obtained in the field during test drilling. Monitor wells were constructed in such a way as to obtain a maximum amount of information while also providing the flexibility of utilizing a monitoring well for contaminate retrival purposes, if necessary.

Drilling in carbonate rock presents particularly difficult construction problems. To construct a typical water well, it may be necessary to install as much as 150 to 200 feet of casing in a hole to prevent caving and/or turbidity problems. Once casing is installed to these depths, there is no

guarantee that any water will be obtained in the next 50 or 100 feet of drilling. For these reasons the drilling contractor was instructed to install a sufficient amount of casing to minimize the possibility of hole collapse, but not necessarily to prevent the occurrence of turbidity problems. Drilling was then to continue inside the casing to a depth five feet beyond the first water producing fracture or weathered zone. It was felt that constructing monitoring wells in this manner would minimize the likelihood of "casing off" badly contaminated water producing zones and would reduce the likelihood of having to drill to an extreme depth.

The locations of all monitoring wells were selected in the down gradient directions of anticipated groundwater flow. Their locations were approved in the field prior to drilling by DER hydrogeologist, Marilyn Hewitt. The locations of all monitoring wells are indicated on Figure 3. More exact locations are given in Figure 4 (for the plant area) and in Figure 5 (for the former disposal area). Details pertaining to each monitoring well, including a cross section of the materials penetrated and construction details are found in Appendix B.

Test drilling determined that the overburden on the Chemclene property was at least 50 feet thick and composed of materials with an uneven distribution both in size and lithology. Bedrock encountered during test drilling was for the most part slightly weathered to very weathered grey to buff limestone and dolomite.

Monitor well construction encountered many problems associated with attempting to complete wells in carbonate rock terrains. Monitor Well CC-1 collapsed several times during drilling. For this reason, it was decided to insert a 4" diameter pvc screen into the hole and stabilize it with a gravel pack. Attempts to insert the 4" screen and riser pipe beyond the bottom of the 6" casing in the well were

LOCATION MAPS
FIGURE 4

Project: Chemclene Corp

Well Plant Area Chemclene Corp

State: Pennsylvania

County: Chester

Town/Township: East Whiteland

Street:

Tract:

Topographic setting: valley

Physiographic province: Piedmont

Geologic formation: Colluvium over carbonates

Longitude:

Latitude:

Elevation at surface: ~ 3 '

Flood elevation: none

Flood potential: none

Locations also plotted:

Access problems: none

Site plan prepared by:

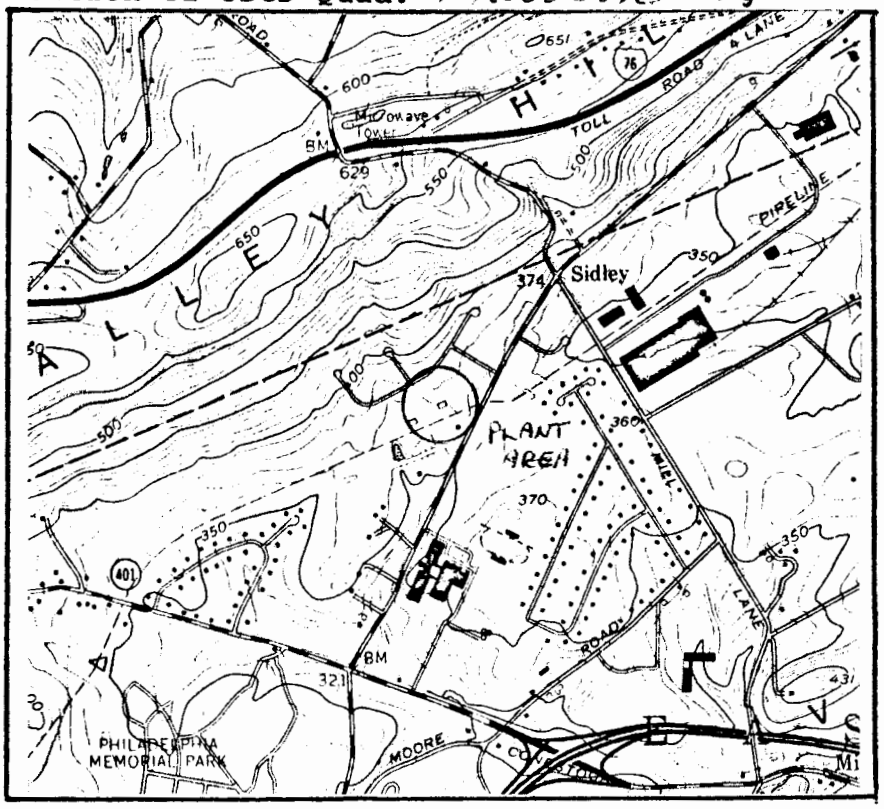
Identified on plot plan:

wells	roads
springs	property l'ns
pipelines	electric l'ns
surface water bodies	

Site/Well identified by: Stakes Casing

Completed by: T. Moorehead
Date: 9/80

Portion of USGS Quad: Malvern 7½ min



Date: photo revised 1973 Scale: 1"=2000'
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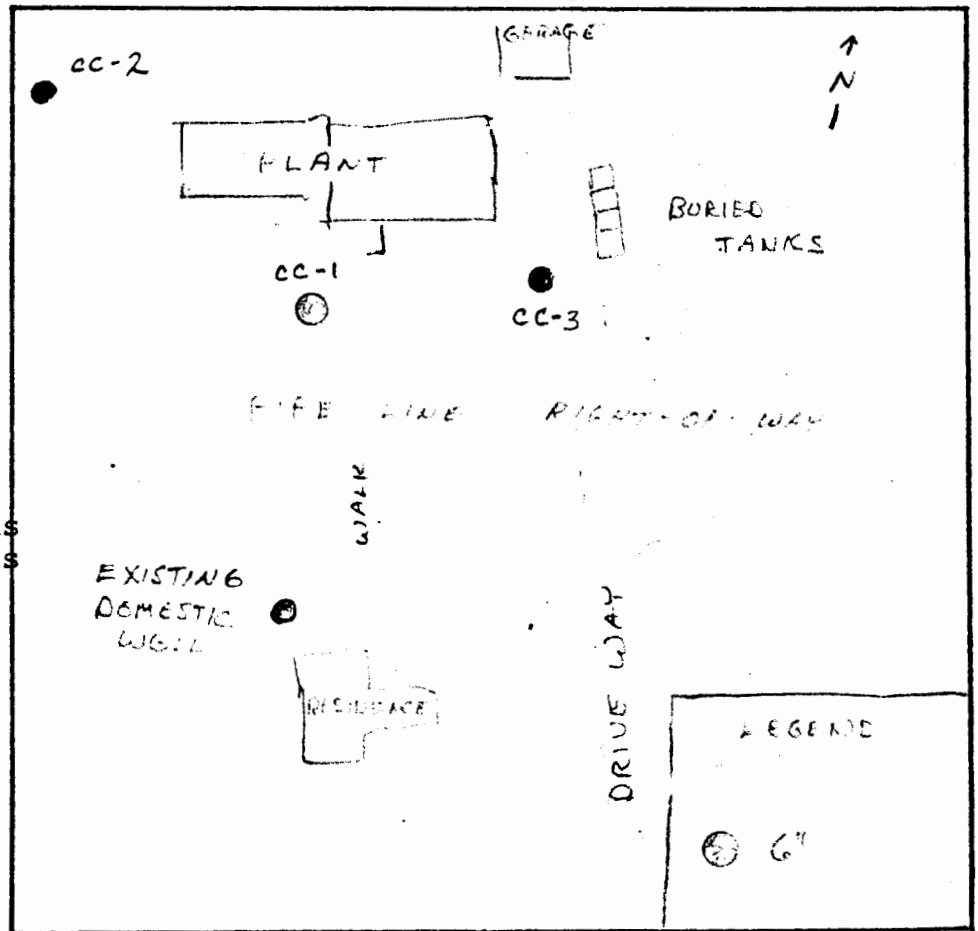
SITE PLAN



Date: Sept 1980 Scale:
Contour Int:

LOCATION MAPS
FIGURE 5

Project: Okemelene Corp

Well Okemelene Corp.

State: Pennsylvania

County: Chester

Town/Township: East Whiteland

Street: Behind Hallbrook Circle

Tract:

Topographic setting: Valley - side hill

Physiographic province: Piedmont

Geologic formation: Colluvium over Conshocken

Longitude:

Latitude:

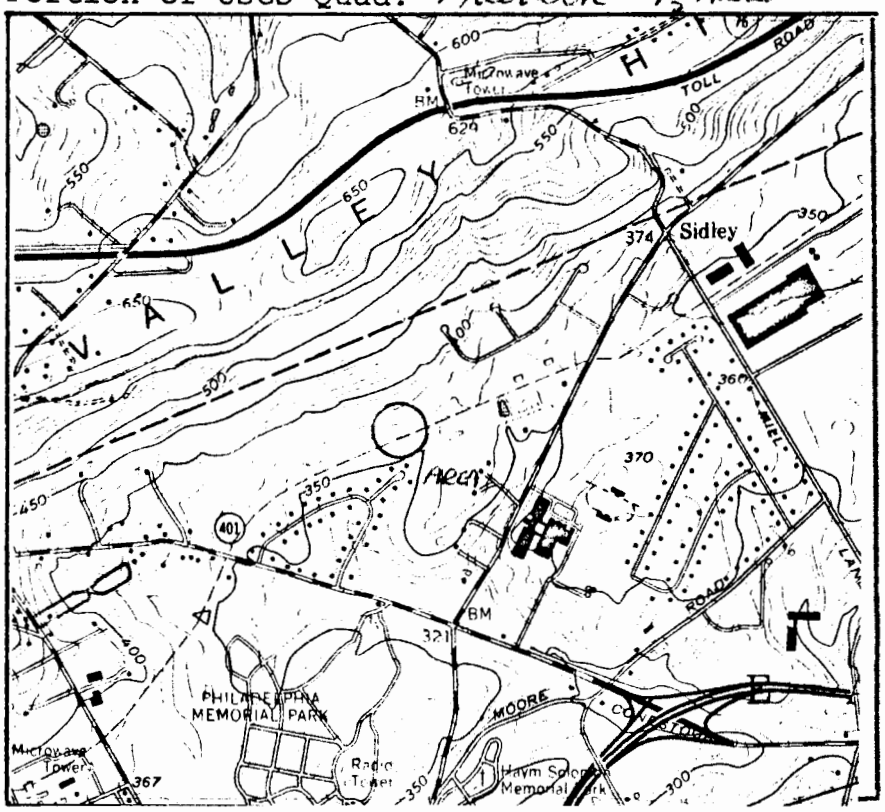
Elevation at surface: 360 - 370'

Flood elevation: none

Flood potential: none

Locations also plotted:

Portion of USGS Quad: Malvern 7½ min



Date:

Scale:
Contour Int: 10'

Access problems:
See Okemelene

Site plan prepared by:
T. Moorhead

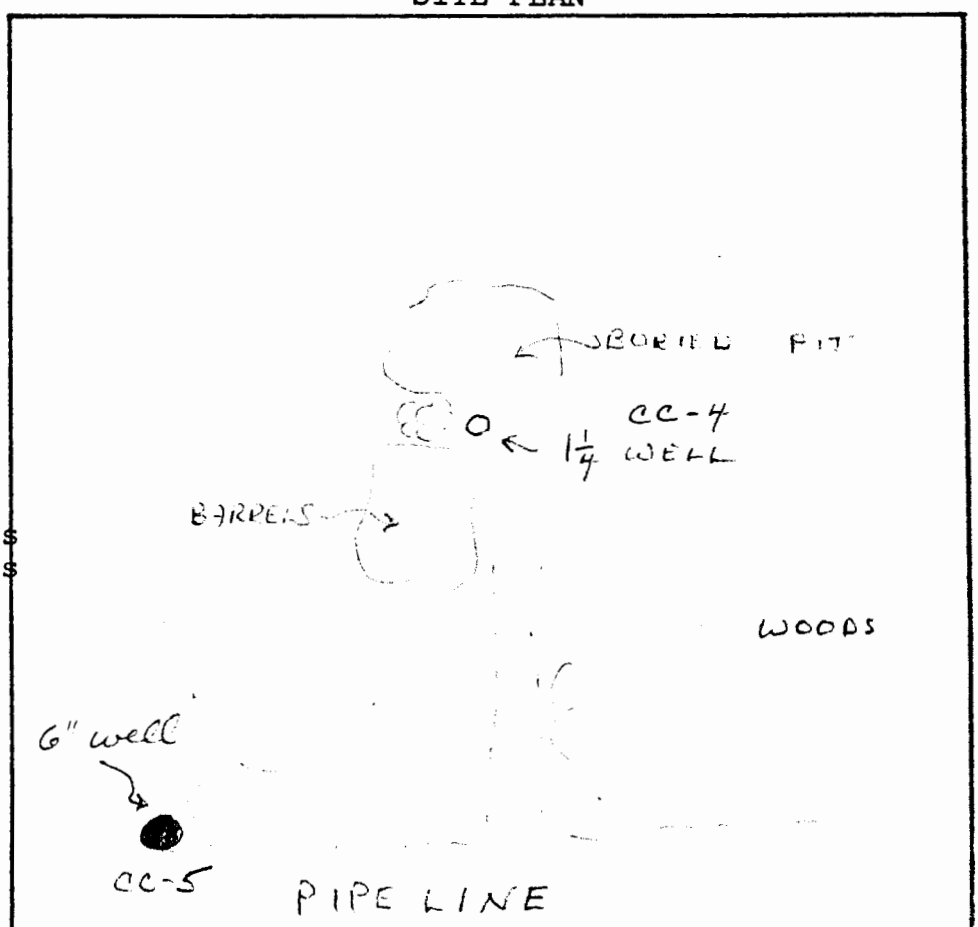
Identified on plot plan:

- ✓ wells
- ✓ roads
- springs
- property l'ns
- ✓ pipelines
- electric l'ns
- surface water bodies

Site/Well identified by:
Stakes - well casing

Completed by: T. Moorhead
Date: 9/80

SITE PLAN



Date: Sept 1980

Scale: none
Contour Int: none

unsuccessful. (It may be possible to use drilling mud and install a 2" diameter screen and gravel pack in Monitor Well CC-1, if it is decided to rehabilitate this well in the future.) The screen originally designated for CC-1 was then installed in Monitor Well CC-3 as a precaution against possible future collapse in that well.

In order to determine the relative interconnection between wells in the plant area, a sensitive water-level recorder was placed on CC-1 and CC-2 during the construction of wells CC-2 and CC-3 respectively. The recorder indicated a slight (.05 foot) response in each of these wells when the other wells were being drilled. The small degree or relative lack of response between the wells can be attributed to their relatively low yield or to the lack of sufficient permeability between them.

Upon the completion of all construction, the monitoring wells were developed with air until turbidity had decreased to a reasonable degree. Due to constraints imposed during construction and on-site overburden conditions, it is probably impossible to ever develop these wells so that turbidity-free water can be obtained.

Water Level Measurement

A considerable amount of water-level data had been collected from area wells during the previous, 1977-1978 investigation. Additional data was collected from these same wells and new wells as part of the present investigation. The new wells including the monitoring wells constructed on the Chemclene property, wells drilled for homes constructed since 1978 and wells not measured during the previous investigation.

All water-level measurements were made from pre-established measuring points, usually the lip of a well seal or the well casing. The elevations of many of these measuring points had been determined as part of the 1977-1978 investigation. The elevations of new wells, including the monitoring wells, were

determined for Moorshead-Siddiqui and Associates by the Philadelphia Suburban Water Company. (On behalf of the Chemclene Corporation, Moorshead-Siddiqui and Associates would like to express our appreciation to the Philadelphia Suburban Water Company for this work.)

Water-level measurements made during the present investigation and selected water-level measurements collected previously are provided in Appendix C. The numbers of the wells indicated on the measurement forms coincide with the numbers given to the wells during the inventory phase of the investigation. In addition the locations of all wells measured are indicated on Figure 3. The water-level elevations in each well have been calculated by subtracting the depth to water from the elevation of the measuring point. The elevation data was then used to produce appropriate water-level contour maps of the area (see Figure 6).

Collection of Water Samples

Water samples were collected from area wells and from the monitoring wells on a variety of different occasions. As previously discussed, the most complete collection and analysis of water samples took place in May and June of 1980. Since that time additional samples have been collected particularly from the monitoring wells on the Chemclene property.

All samples taken during the investigation were collected using accepted procedures and sample containers approved for the sampling of chlorinated hydrocarbons. Samples were taken to laboratories as soon after collection as possible. If any delay was anticipated between the time samples were collected and the time they would be analyzed, they were stored under refrigeration. Domestic wells were sampled at the closest point to the well in each home. Whenever possible, samples were collected ahead of water conditioning or treatment equipment. Results of an analysis of samples collected from area wells appears in Table 1.

TCE Concentrations

Well No.	Concentration	Well No.	Concentration	Well No.	Concentration
1	0.0	24	N.S.	47	0.0
2	0.0	25	0.0	48	0.0 DER
3	0.0	26	N.S.	49	0.0
4	0.0	27	N.S.	50	0.0
5	2.5	28	N.S.	51	.5
6	32.4	29	N.S.	52	0.0
7	0.0	30	N.S.	53	0.0
8	0.0	31	N.S.	54	0.0
9	75.6	32	N.S.	55	0.0 DER
10	1330.0	33	N.P.	56	14.3
11	N.S.	34	N.S.	57	11.4
12	N.S.	35	1.2	58	2.9
13	N.S.	36	2.6 DER	59	0.0
14	N.S.	37	N.S.	60	0.0
15	27.0	38	N.S.	61	0.0
16	8.8	39	N.S.	62	N.S.
17	15.0	40	N.S.	63	0.0
18	N.P.	41	190.5	64	0.0
19	13.3	42	0.0	65	.12
20	.3	43	0.0	66	N.P.
21	N.P.	44	.5	67	.4
22	N.P.	45	0.0	68	N.D.
23	13.0	46	0.0	69	N.D.

NOTE: N.S. - not sampled, not in study area or a non-flowing spring
N.P. - no pump
DER - result obtained from DER
N.D. - not drilled at the time of sampling

Table 1 - Results from water samples collected from wells in the vicinity of the Chemclene Corporation, Frazer, Pennsylvania. The wells were sampled May 8 and 9, 1980, and June 13, 1980, and analyzed for TCE. All results are in micrograms/liter.

Water samples were collected from Monitoring Wells CC-2, CC-3 and CC-5 on May 7, 1981, using a portable electric submersible pump and generator. Monitor Well CC-4 was not sampled because the water level had dropped below the bottom of the screen in the well. Monitor Well CC-1 was not sampled because the well had collapsed to a point at or above the water level in the well. If the water level rises in either of these wells, it may be possible to collect water samples from them.

A procedure for sampling the monitoring wells was selected to minimize cross contamination from well to well. This was accomplished by pumping the least contaminated well (CC-5) first. Between the collection of each sample, the pumping equipment was thoroughly rinsed with uncontaminated water. Prior to and during sampling, water-level and flow measurements were made in each well. From this information, the relative productivity of each well was then determined. Results of these measurements appear in Appendix D.

Monitor Wells CC-2 and CC-3 were pumped for 60 minutes and sampled at 3 different times. Monitor Well CC-5 was pumped for 30 minutes and was likewise sampled 3 times. The results of the analysis performed on these samples appears in Table 2.

Collection of Soil Samples

Due to the age and nature of the problem and the thickness of the overburden in the area, soil sampling would not provide any meaningful or useable results. For these reasons, the sampling and analysis of soils was not undertaken at either site.

Laboratory Analysis

Samples collected during the investigation were all analyzed by Cedar Grove Laboratories, Downingtown, Pennsylvania. Analysis

Monitor Well	Elapsed Time in Minutes	1,1,1-Trichloroethane	TCE	PCE
CC-2	10	12.4	57.8	7.3
	20	13.3	62.2	7.0
	60	17.0	64.1	3.0
CC-3	30	2,080.	12,600.	1,120.
	40	2,230.	12,600.	1,170.
	60	1,690.	10.500.	885.
CC-5	5	586.	1,180.	861.
	20	627.	1,310.	904.
	30	572.	1,270.	743.

Table 2 - Results of chlorinated hydrocarbon analysis of Chemclene monitoring wells, Samples collected May 7, 1981. All results in micrograms per liter.

were performed on a Perkin-Elmer, Sigma-1, gas-liquid chromatograph with electron capture detectors. Liquid-liquid extractions were made using approved techniques. Detection limits to a level of .05 micrograms/liter were possible with this equipment.

ANALYSIS OF RESULTS

Flow System Description

The groundwater flow system in the vicinity of the Chemclene property is fairly typical of that developed on the edges of carbonate vallies in southeastern Pennsylvania. Work undertaken during the present investigation further defined and quantified the groundwater flow system both in terms of flow directions and contaminate concentrations. In trying to define the subsurface flow system in the area it must be realized that the system changes with time. Seasonal periods of groundwater recharge, difficient recharge due to drought, artificial withdrawals from wells and quarries all combine to effect the flow system both in time and space. During 1981 the Chemclene property and surrounding area were subjected to drought conditions as was most of southeastern Pennsylvania. During this period water levels in wells dropped to near record lows. Water levels collected during January 1981 averaged 3.7 feet lower than the average levels measured in wells during the investigation undertaken on behalf of the Hillbrook Circle residents in 1977 and 1978. Depressed water levels due to drought combined with the increased discharge from the Great Valley Well and quarries in the Devault area have resulted in a locally suppressed water-table. The water-level contour map prepared from a compliation of water-level data collected during January 1981 (see Figure 6) indicates two major flow directions in the area of the Chemclene property. Ground water south of Hillbrook Circle flows toward the Great Valley Well. Groundwater flow in the vicinity of the former disposal area and the plant area is northeastward toward Devault and Cedar Hollow. The flow direction toward Devault parallels major faults mapped in the area.

Due to the high permeability in the carbonate rocks underlying the area, the water-table is relatively flat. Only a 5-foot difference in water-table elevation exists over most of the area. The lack of water-table relief makes constructing contour maps more difficult. Groundwater velocities in the area on the order of 10 to 100 feet per day are probable especially along open fault and fracture zones.

The present groundwater flow regime depicted in Figure 6 explains in part the pattern of contamination depicted in Figure 7. Since the pattern of groundwater flow has changed in time due to drought; residual areas of contamination can be expected to remain in the area adjacent Phoenixville Pike (area A) and in Hillbrook Circle (area B).

Subsurface Distribution of Chlorinated Hydrocarbons

The results of the analysis of samples collected during 1980 and 1981 were used to prepare the concentration contour map indicated on Figure 7. TCE concentrations were used as an indicator parameter for the purposes of delineating contamination patterns. As expected Figure 7 indicates that two principal areas having high TCE concentrations are present in the area. These areas are under the plant and the former disposal area. Other areas having much lower concentrations are designated as areas A, B, and C and are indicated on Figure 7. While possibly related to the two main areas, these additional areas are thought to be distinct enities having their own origins and explanations.

Plant Area Contamination

While the total extent of contamination emanating from the plant area was not defined due to limitations in obtaining places to drill monitor wells, it can be said on the basis of data collected to date that a plume of TCE and other chlorinated hydrocarbons will be found trending in a northwest direction toward the quarry operations in Devault.

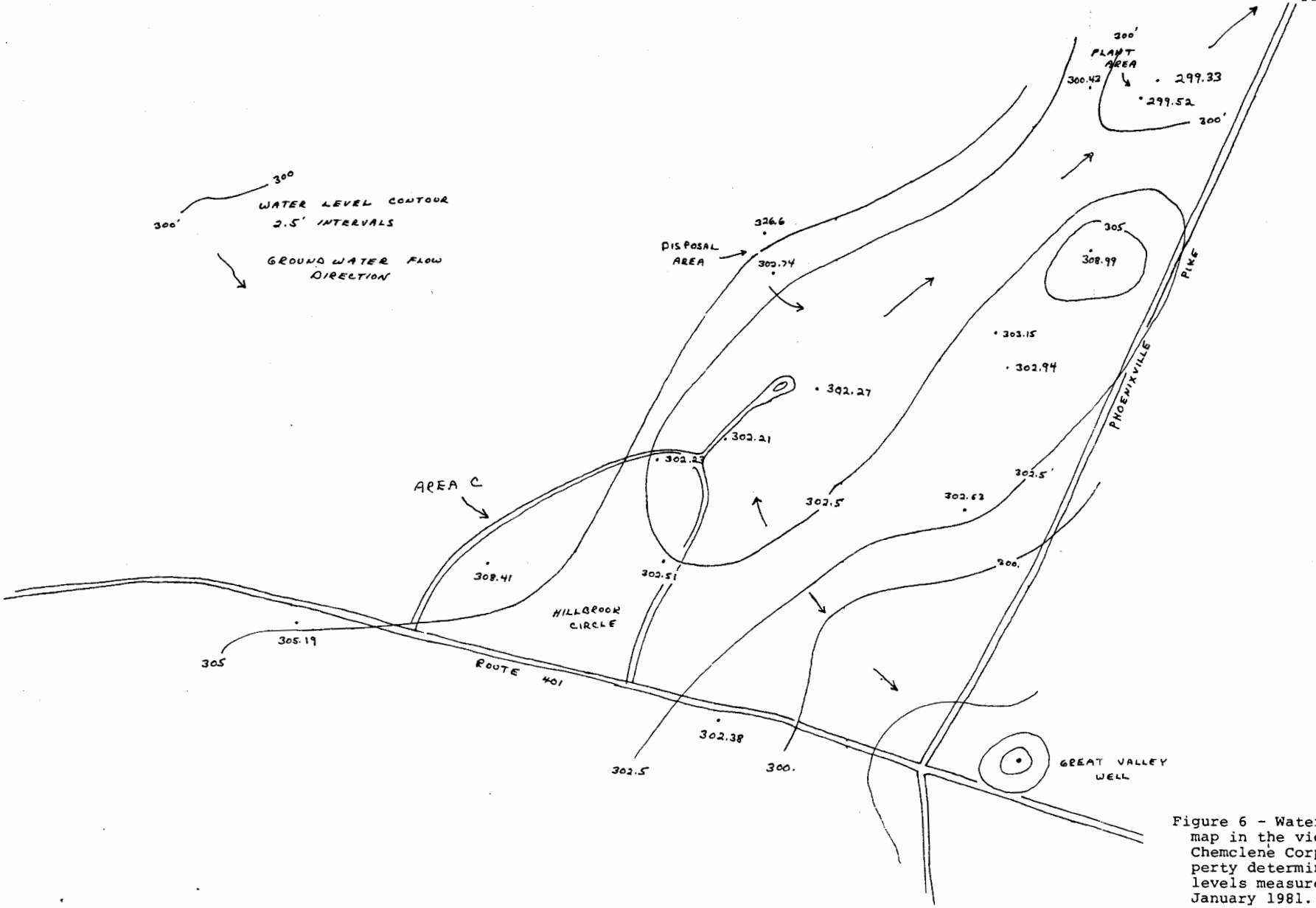


Figure 6 - Water level contour map in the vicinity of the Chemclene Corporation property determined from water levels measured during January 1981.

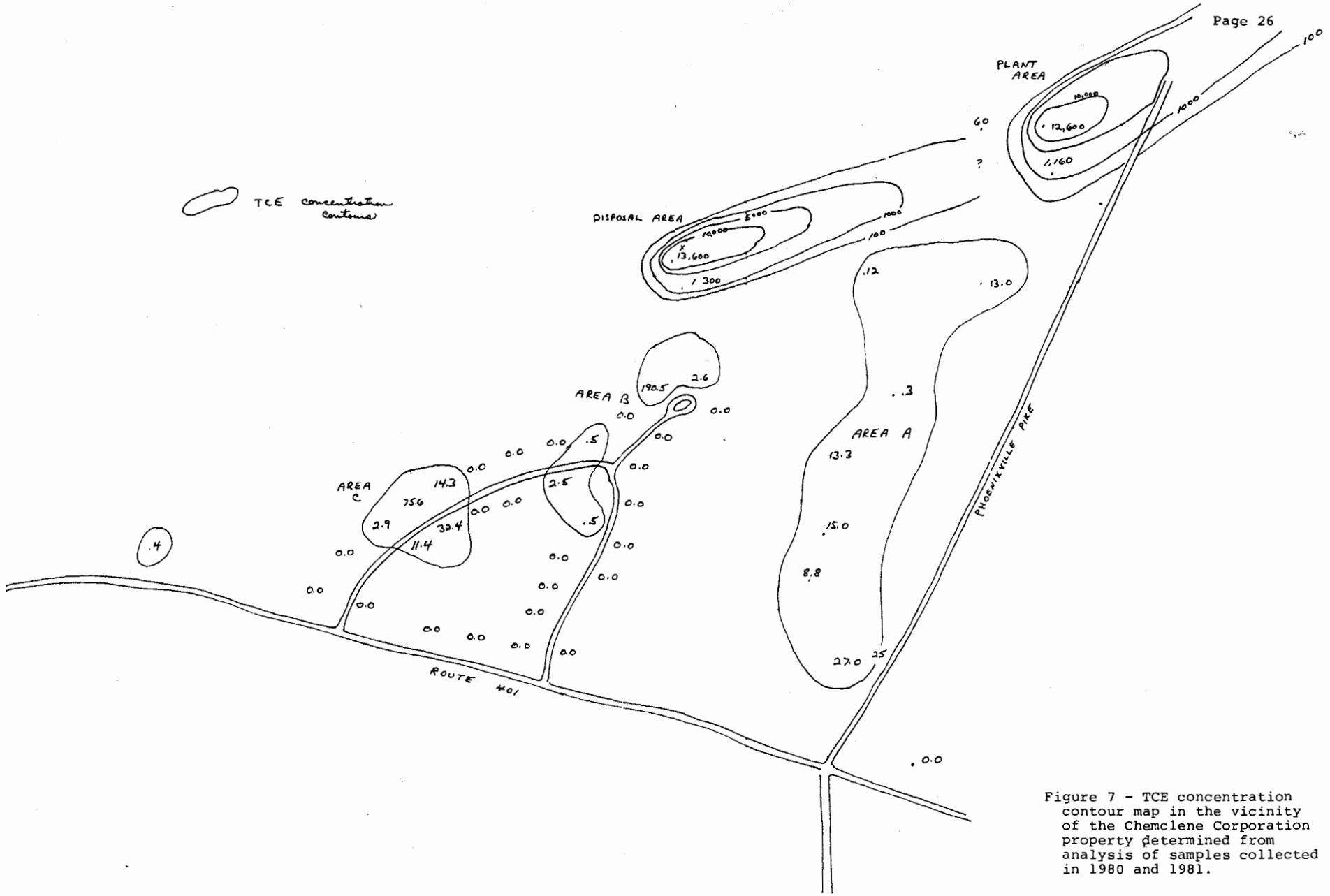


Figure 7 - TCE concentration contour map in the vicinity of the Chemclene Corporation property determined from analysis of samples collected in 1980 and 1981.

The plume's axis is along a major fault and concentrations probably diminish in a down gradient direction fairly rapidly. Since there are no wells in that direction because everyone is using public water, there are no sampling points from which samples can be collected to determine exact concentrations. The Martin-Marietta Corporation was contacted to obtain permission to sample their sump but to date they have not responsed in a positive manner.

Former Disposal Area Contamination

As expected, significent concentrations of chlorinated hydrocarbons including TCE were found in monitor wells CC-4 and CC-5 at the site of the former disposal area. Based on the evidence at hand, it appears that subsurface discharge from the former disposal area also moves northwest from the site toward the Devault area. Movement is undoubtedly along the same fault which underlies the plant site. Contamination emanating from the former disposal area possibly overlaps and becomes indistinquishable from that once contributed in the area of the plant.

Area A Contamination

TCE levels within area A are probably the result of a residual distribution of a contamination plume left over from when the flow system had a much different pattern than it does today. Before the groundwater trough created by pumping in the Devault area " captured" groundwater flow under the Chemclene property, flow was probably toward Valley Creek. Contamination from the plant site probably resulted in the formation of a significant plume along flow lines in that direction. As the flow pattern changed and recharge in that area caused concentrations to drop the pattern indicated on Figure 7 developed. If present conditions continue, it is expected that TCE levels within area A will contine to slowly diminish.

Area B Contamination

An explanation for the presence of TCE in 5 wells within area B is similar to that offered for area A except that the original source of TCE is more likely the former disposal area than the plant area. As long as flow patterns remain as indicated on Figure 6, TCE levels should likewise diminish with area B. Samples should be taken from time to time from wells in both areas A and B, not only to check carbon filter performance but also to determine future long-term trends.

Area C

The source of TCE in wells with in area C in Hillbrook Circle is unknown. Because flow and geochemical patterns do not indicate that the former disposal area could be a present or past source of contamination within area C, it is assumed that an alternative source is responsible. Two possible sources are suggested. Clogged septic systems have been a continuous problem in the Hillbrook Circle area. It is very possible that one or more residents within area C have used a drain and tile field cleaner having a chlorinated hydrocarbon base. Such septic system cleaners were commercially available and widely used in the past. Possible use of septic system cleaners have been used to explain many anomalous levels of TCE (in the 0 to 150 ppb range) in other areas not related to this study.

A second possible explanation for the presence of TCE within area C is that an episode of clandestine dumping took place behind Hillbrook Circle. Undetected access from Route 401 is available along the abandoned railroad right-of-way and the gas pipe line. Trucks known to have carried chlorinated hydrocarbon wastes frequented 401 on their way to a disposal area on Worthington Road not far from Hillbrook Circle. When conditions were not favorable for dumping at Worthington Road, a truck could have easily slipped undetected into the woods behind Hillbrook Circle.

Levels in area C should also be monitored and if they do not diminish then a separate investigation should be undertaken by DER in this area to determine materials present and their relative ratios.

AQUIFER RECLAMATION

Site Clean Up

Delineation of a groundwater quality problem only becomes meaningful if corrective actions are taken when warranted. Corrective actions can include preventing any additional contamination from occurring in the future and undertaking reasonable clean up efforts to help to restore the aquifer to its original quality. Even before the initial phases of the present groundwater investigation were completed, the Chemclene Corporation moved systematically to remove any potential future source of groundwater contamination. These steps included the following:

1. Placement of a concrete pad under the bulk loading and unloading area at the plant.
2. Disposal of condensate water from the distillation process at an approved facility off-site.
3. Termination of any outside drum storage.
4. Implementation of an employee safety training program with particular emphasis on spill prevention and control.
5. Elimination of the backlog of drums waiting for disposal by at least 1,000.
6. Initiation of the removal and proper disposal of drums from the former disposal area.

Removal of the contents of the former disposal area and associated contaminated soils should eventually solve the groundwater contamination problem in that area. No removal or retrival wells at the site are recommended at present. The plume of contamination threatens no wells or uncontaminated portions of the aquifer. If groundwater flow patterns were to alter as a result of letting the quarries at Devault fill with water then a decision to construct containment wells might be reconsidered.

Removal Well - Plant Area

Due to the size of the existing plume and the age of the present problem, extensive aquifer reclamation is not practical or presently necessary. However a retrival well near the plant could significantly reduce chlorinated hydrocarbon concentrations in the aquifer at that point and could significantly reduce the time needed for down gradient aquifer recovery.

Details concerning the implementation of a retrival well system will have to be approached on an experimental basis with DER's cooperation and approval. Elements of the retrival well system would include:

1. Deepening, reconstructing or moving Well CC-3 to develop a yield of between 35-45 gpm (this yield should provide an effective cone of influence in the area).
2. Developing insitu air injection or air lift techniques to reduce chlorinated hydrocarbon concentrations prior to additional treatment and disposal.
3. Pumping effluent to a properly designed and managed spray area to provide additional removal and ultimate disposal.

Water available from the retrival well system could be used for purposes such as space heating (groundwater heat pump) or boiler cooling. Techniques to locally recharge the groundwater reservoir and "flush" the overburden of contaminates might also be tried.

CONCLUSIONS

Based on hydrogeological investigations conducted by Moorshead-Siddiqui and Associates in the vicinity of the Chemclene Corporation property from 1977 through the present, the following conclusions are made:

1. Hydrogeologic conditions in the vicinity of the Chemclene property are complex but definable.
2. Groundwater movement from the former disposal area and the plant area is presently northeastward toward the quarries in Devault.

3. The groundwater contamination problem in the vicinity of the Chemclene property is an old one, more or less, in equilibrium with the present flow system.
4. Large scale withdrawals to quickly remove contaminated water or alter existing flow patterns is not practical, economically feasible or necessary at this time.
5. All wells with TCE concentrations greater than 4.5 mg/l have been equipped with carbon filters as a precautionary measure.
6. No uncontaminated wells or uncontaminated portions of the aquifer appear to be threatened by the existing situation.
7. Removal of materials from the former disposal area and prevention of any leaks or spills at the plant site should prevent the continued contamination of the aquifer.
8. Removal and treatment of 35-45 gpm in the vicinity of the plant should affectively control the problem in that area.
9. Dilution and the natural and artificial discharge of contaminated water from the aquifer underlying the Chemclene property will eventually reduce concentrations in the aquifer to acceptable levels.

RECOMMENDATIONS

Based on the conclusions reached as a result of our investigation, Moorshead-Siddiqui and Associates offers the following recommendations:

1. Continue the clean up activities at the former disposal area. This would include the eventual excavation and removal of all buried materials including badly contaminated soils at the base of the excavation. Clean up could take place over an extended time frame due to the age of the problem and present site conditions.
2. Surface drainage should be redefined in the vicinity of the excavation to minimize the inflow of surface water.
3. As excavation at the former disposal area proceeds, an investigation of techniques to best minimize groundwater inflow and outflow should be undertaken.
4. Efforts to prevent the recontamination of soils in the vicinity of the plant area should continue.
5. Well CC-3 should be deepened, reconstructed or moved so as to provide a yield of 35-45 gpm for removal purposes.

6. This well should be operated on a more or less continuous basis to provide containment and to remove chlorinated hydrocarbons from the aquifer.
7. Disposal of water from the containment and removal well could be through a spray irrigation system situated on the pipe line right-of-way or in the woods west of the plant. A variety of insitu aeration techniques should be investigated to significantly reduce TCE levels in the well prior to spraying.
8. Water pumped from any well might first be used to heat and cool the plant (using a groundwater heat pump) or might be used for other purposes prior to disposal.
9. Monitoring should continue in selected wells on a twice a year basis until levels of chlorinated hydrocarbons are reduced to acceptable levels.
10. No new wells should be constructed between the Chemclene property and the quarries in Devault until levels in the aquifer reach acceptable levels.